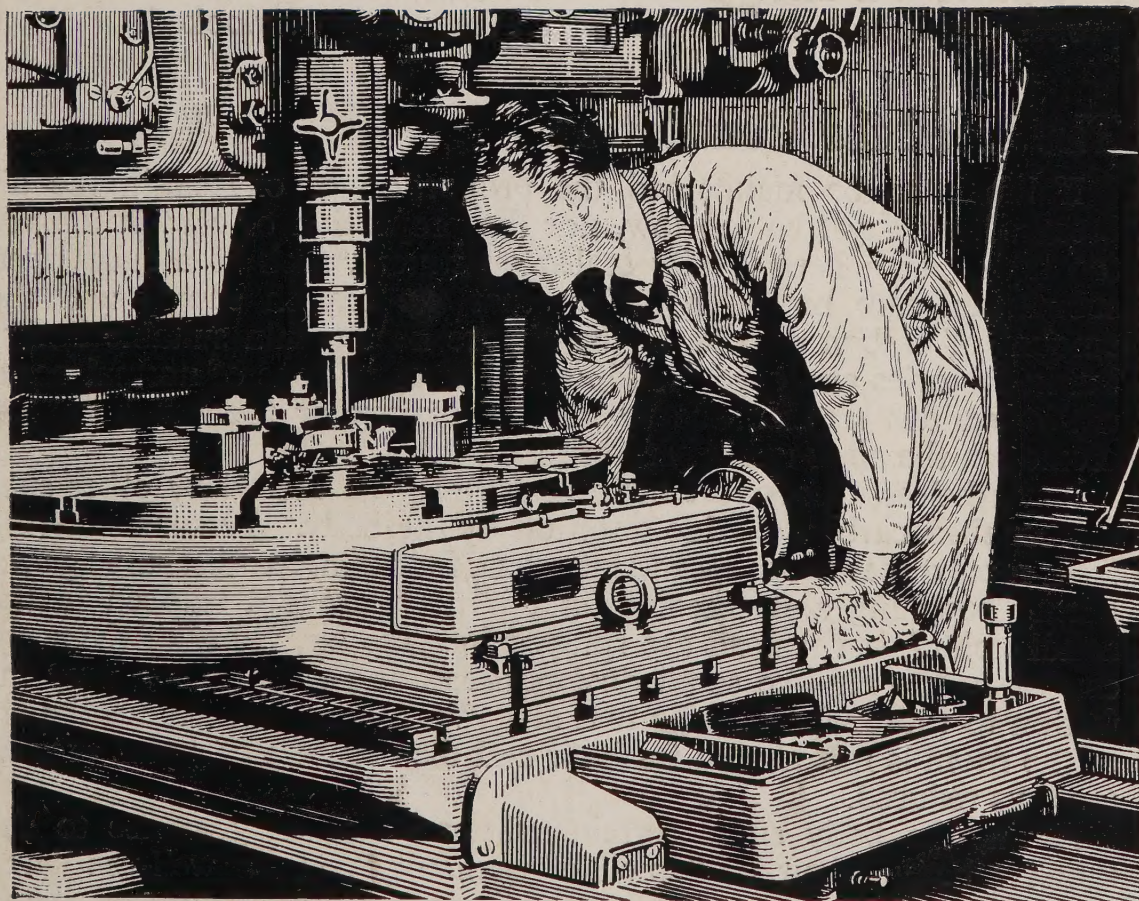


010 (07)
Conditions for Industrial Health and Efficiency

Pamphlet No. I

**ISSUED BY THE INDUSTRIAL HEALTH RESEARCH
BOARD OF THE MEDICAL RESEARCH COUNCIL**

VENTILATION AND HEATING



LIGHTING AND SEEING

LONDON: HIS MAJESTY'S STATIONERY OFFICE

Price Threepence



Ventilation and Heating

Introduction

Our health, comfort, and efficiency are greatly influenced by the environment in which we live and work. Abnormal variations in the quality of the air we breathe, or in the temperature to which we are exposed, hinder the proper working of our bodies. Research in factories and mines has shown that unsatisfactory atmospheric conditions, besides causing discomfort, lead to reduced production, increased sickness, and make the workers more liable to incur accidents. In time of war, when every effort is needed to ensure maximum production, it is more than ever necessary that attention be paid to proper ventilation, and yet the need is frequently overlooked.

The Need for Ventilation

If life is to be maintained the proportion of oxygen in the air breathed must not be too low, nor the proportion of carbon dioxide too high. In a hermetically sealed apartment, such as a submerged submarine, care has to be taken that the oxygen supply and the amount of carbon dioxide in the air are kept within suitable limits; but in factories and other buildings under conditions of normal occupation serious trouble due to lack of oxygen or too much carbon dioxide in the air is unlikely to arise.

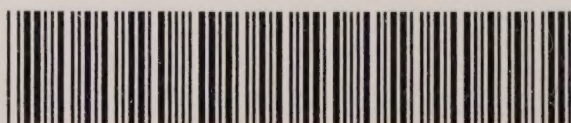
Nevertheless, discomfort or ill-health may be caused by other substances than carbon dioxide given off by the body. Persons suffering from some diseases—colds and influenza, for example—discharge germs during coughing and sneezing, and if these are not trapped in the handkerchief, but instead are sprayed into the air, many of them are carried in the air like small dust particles and may later convey infection to those who breathe that air. With good ventilation, the air of the room is mixed with fresh air and the numbers of germs present are thus reduced.

Again, the body emits certain substances which give rise to the familiar body odour or “smell of humanity”. In a well-ventilated room these odours are generally unnoticeable, but in a badly ventilated room they may be objectionable or, to some persons, even nauseating. There is some evidence that prolonged exposure to these odours, even when they are not present in objectionable strength, reduces the appetite for food.

The Amount of Fresh Air Required

For very many years, standards of fresh air supply for purposes of ordinary ventilation have generally been based on the amount of air necessary to dilute body odours to such an extent that they are un-

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noticeable, or at any rate inoffensive. The amount of fresh air necessary to render these odours imperceptible varies with different people and from time to time, but, as a round figure, the fresh air supply should be at the rate of not less than about 1,000 cubic feet per hour for each person, or about 17 cubic feet per minute. Such a quantity of fresh air is highly desirable even in winter time, but in summer it should be greatly exceeded.

From the standpoint of preventing the spread of infection, the greatest amount of ventilation that can be secured with comfort is to be desired.

In many industrial processes injurious dusts, vapours or gases are given off, and sometimes these products are dispersed into the general atmosphere. In such cases the ventilation must be sufficient to ensure that the concentrations of these substances do not reach a harmful level. For certain processes, minimum ventilation requirements are prescribed by Regulations.

Warmth and Comfort

The living body is constantly generating heat, even when at rest; and when physical work is being performed the heat production rises considerably. In order that the body temperature may remain approximately constant, as it must if health is to be maintained, this heat must be dissipated as quickly as it is produced, otherwise there would be storage of heat and the body temperature would rise, possibly to a dangerous level. On the other hand, the rate of heat loss must not be too rapid, or chilling will result.

The rate at which heat is lost from our bodies—and our feelings of warmth—are influenced by the amount of physical work that we are doing, by the amount of clothing worn, and by the warmth of our environment. The familiar measure of warmth is the temperature of the air as indicated by the ordinary thermometer; but other important factors are the humidity and rate of movement of the air, and the temperature of the walls and other solid surroundings. With the same air temperature, increased movement of the air, increased dryness, and cooler walls, all tend to make us feel cooler.

(a) *Desirable Temperatures.* During cool weather in Great Britain, persons doing sedentary or very light work are generally comfortable when the air temperature is about 65° F. Unless the temperature of a workroom is under automatic control, it is rarely possible to avoid some variation of temperature during the course of the working day. Observations made on some thousands of persons have shown that, for light work, temperatures ranging from 60° to 68° F. are usually satisfactory; so that, although where possible a temperature of 65° F. is desirable, temperatures a few degrees lower are permissible when in the national interest fuel economy is a matter of urgency. It will be remembered that the Factories Act, 1937, requires that in rooms where a substantial proportion of the work is done sitting and does not involve serious physical effort the temperature must not be below 60° F. after the first hour of work. Even when there is no fuel shortage,

temperatures above 68° are undesirable in cool weather, for higher temperatures tend to cause inefficiency as well as discomfort.

People who are doing active physical work require lower environmental temperatures than sedentary workers. For active yet light work, the temperature should be about 60° to 65° F., and for some of the more strenuous work done in factories, a temperature of between 55° and 60° F. is generally found satisfactory.

In hot weather it will usually be impossible to keep factory temperatures down to the maximum values suggested above for winter, but such temperatures are not really desirable in very warm weather. During the summer we become acclimatised to higher temperatures, and we commonly wear lighter clothing, so that warmer indoor temperatures are tolerable. With good ventilation it will generally be possible to maintain an indoor temperature in summer that is only slightly above the outside temperature. Where air conditioning plant is available, the temperature indoors should not generally be more than 10° F. below that prevailing outside.

(b) *Radiant Heat.* In winter, the internal surfaces of the walls and roofs of lightly constructed buildings may be several degrees cooler than the general air of the shop. Owing to the radiation of heat from their bodies to these cold surfaces, persons working near such walls may need some extra radiant heat, or a rather higher air temperature than would otherwise be necessary. In other cases, where considerable radiant heat is given off from heating apparatus or manufacturing plant, it may be desirable to compensate for this by some reduction in the air temperature, or by increasing the rate of air movement.

(c) *Air Movement.* During the winter months the average speed of air movement in the ordinary factory is usually greater than 20 feet per minute, and it generally averages about 30 feet per minute. In summer, more rapid movement is highly desirable. Out of doors in warm weather we find a breeze very refreshing. Indoors, too, a good rate of air movement is invigorating, while a stagnant atmosphere is oppressive and causes feelings of stuffiness. Even at comfortable temperatures in winter, the air movement should not be much below 20 feet per minute, and, in summer, or in hot factories, air movement becomes much more important. In summer, especially, full use should be made of whatever arrangements for ventilation are provided, so that a refreshing atmosphere can be ensured.

The provision of adequate air movement is of great importance, but at the same time objectionable draughts should be avoided. Our sensitivity to draughts increases rapidly as the temperature of the air falls, so that an air current which would be quite pleasant in a warm room would be liable to provoke complaints if the temperature were lowered by several degrees. People vary greatly in their sensitivity to draughts.

Ventilation Arrangements

We speak of natural ventilation and of mechanical ventilation. The latter term is used when mechanical power operates fans, which

blow air into a building or which extract air. In natural ventilation no mechanical power is used, and the ventilating power of natural agencies is employed. These agencies are the force of gravity and the motive force of the wind.

Warm air is lighter than cool air, so that when the air of a building is warmed it tends to be displaced by heavier cool air. Thus, if openings are placed at a low level—say in the walls of the building—and at a

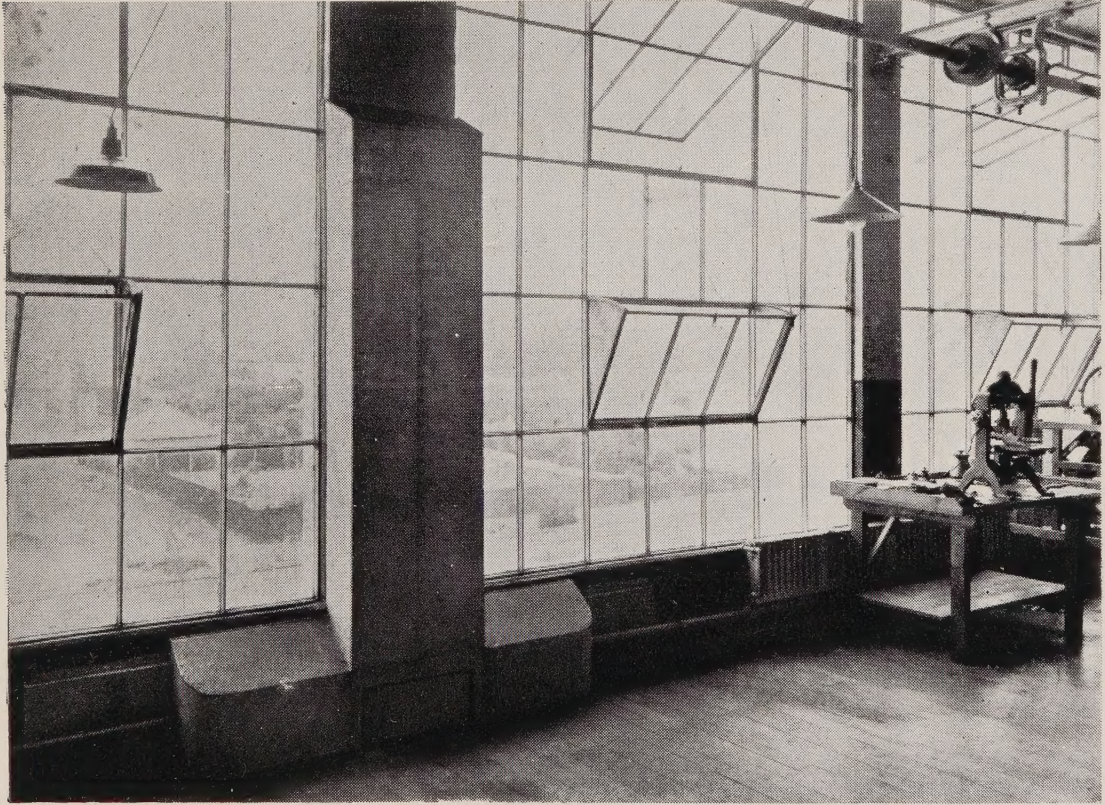


FIG. 1. HOPPER AND SWIVEL WINDOWS PROVIDING LARGE TOTAL AREA FOR NATURAL VENTILATION

NOTE. Under winter conditions, with closed windows, air enters at the Tobin tubes, in which there are hot water radiators for warming the air.

higher level—say in the roof—air currents will tend to be set up, so that warm air passes out through the roof and is replaced by cool air entering through the side openings.

Wind acts in two ways. Direct wind pressure on the exposed side of a building causes air to enter through openings on that side, and to leave through openings on the leeward side. When the wind blows over a freely exposed chimney top, or over a ventilating cowl placed in the roof, it exerts an aspirating action on the air in the chimney or cowl, and sucks it out. Thus, when a building is provided with side windows and with roof cowls, air is blown in through the side openings and extracted through the roof openings.

Narrow factory buildings can generally be satisfactorily ventilated by means of well-designed and suitably placed windows. An excellent arrangement of windows is shown in Fig. 1. Large areas of glass extend almost from floor to ceiling, so that the factory is well lit.

Hopper and swivel windows give wide openings for natural ventilation, and since these are provided along both sides of the building, good cross-ventilation can be obtained in warm weather. The gusset pieces at the sides of the hopper windows are a notable feature. They do much to prevent draughts when the windows are open in cold weather. Between the windows to the left of the picture is shown what is known as a Tobin tube ventilator. Fresh air enters through air gratings near floor level, it then passes over a hot-water radiator concealed within the tube, and finally enters the room from the top of the tube at a height of about 8 feet from the floor. In wider single-storey buildings large modern roof outlets will generally be necessary to secure good natural ventilation.

Openings for natural ventilation should be of generous size, and suitably placed to ensure good distribution of the fresh air without causing draughts. A working rule that has been suggested is that there should be 5 square feet of ventilation opening per 100 square feet of floor area. Such an allowance of openings should provide adequate ventilation even in summer. Where roof cowls are relied upon as outlets, there should be adequate provision of inlets in the walls.

Many workrooms, especially in extensive single-storey factories, cannot be satisfactorily ventilated by natural means. Correctly planned systems of mechanical ventilation are necessary in such cases. In the design of such systems, special attention should be given to the arrangement of air inlets: they should be so designed that they produce adequate air movement, even in summer, without causing unpleasant draughts.

The Effects of the Blackout

The black-out regulations cause little or no interference with ventilation where that is effected by a mechanical system. It is a simple matter to ensure that light is not allowed to emerge from fan openings.

Difficulties arise, however, in naturally ventilated buildings, where we have to rely on windows. Quite often workrooms have been blacked-out by the simple expedient of blocking up all windows and thus virtually abolishing ventilation. This procedure is undesirable and should certainly not be adopted where work continues through the night. Where a night shift is worked, satisfactory ventilation should be contrived. In many cases this can be done by using some form of light trap at the windows. Such a device effectually prevents light from emerging but still allows the free entry and exit of air. In some factories where satisfactory daytime ventilation has been achieved by natural means, it has been found necessary to use fans to secure adequate ventilation in the black-out.

What are known as unit heaters can be used to supplement natural ventilation. Each unit comprises a fan and a heater—often a steam radiator. The fan passes air over the heating surface and thence

propels it forward into the room. A typical installation is shown in Fig. 2.

These units are commonly employed to warm and recirculate the air already in the building, but, by connecting a short, sheet-metal duct



FIG. 2. STEAM-HEATED OVERHEAD INSTALLATION WARMING A LARGE BAY

A series of combined heating and ventilating unit appliances which direct a warm air stream at controlled velocity down to working level.

(Copyright reserved)

to the intake side, such a heater can be made to take its air supply from outside, and it then becomes a true ventilating mechanism. By the insertion of a suitable baffle in the duct, it can be arranged that the heater circulates fresh air or recirculates the air of the factory, as required. At times when the heat supply is shut off, these units taking their air supply from outside can be of substantial value in maintaining pleasant conditions indoors. Properly used, they set up refreshing air currents without giving rise to draughts at working level.

Some Effects of Extreme Temperature Conditions

Some workers who exert themselves strenuously at high temperatures, such as miners in deep mines, ships' stokers, and some iron and steel workers, are liable to suffer from heat cramp. This form of cramp is brought on by drinking large quantities of water to quench the thirst caused by profuse sweating. Sweat contains salt, so that in heavy sweating not only is much water lost from the body, but also a

considerable amount of salt. If large quantities of water are then drunk, the concentration of salt in the blood is reduced, and this may cause painful cramp. If a small proportion of salt (three level teaspoonfuls per gallon) is added to the drinking water, cramp can be avoided.*

Although distressing symptoms such as heat cramp are only likely

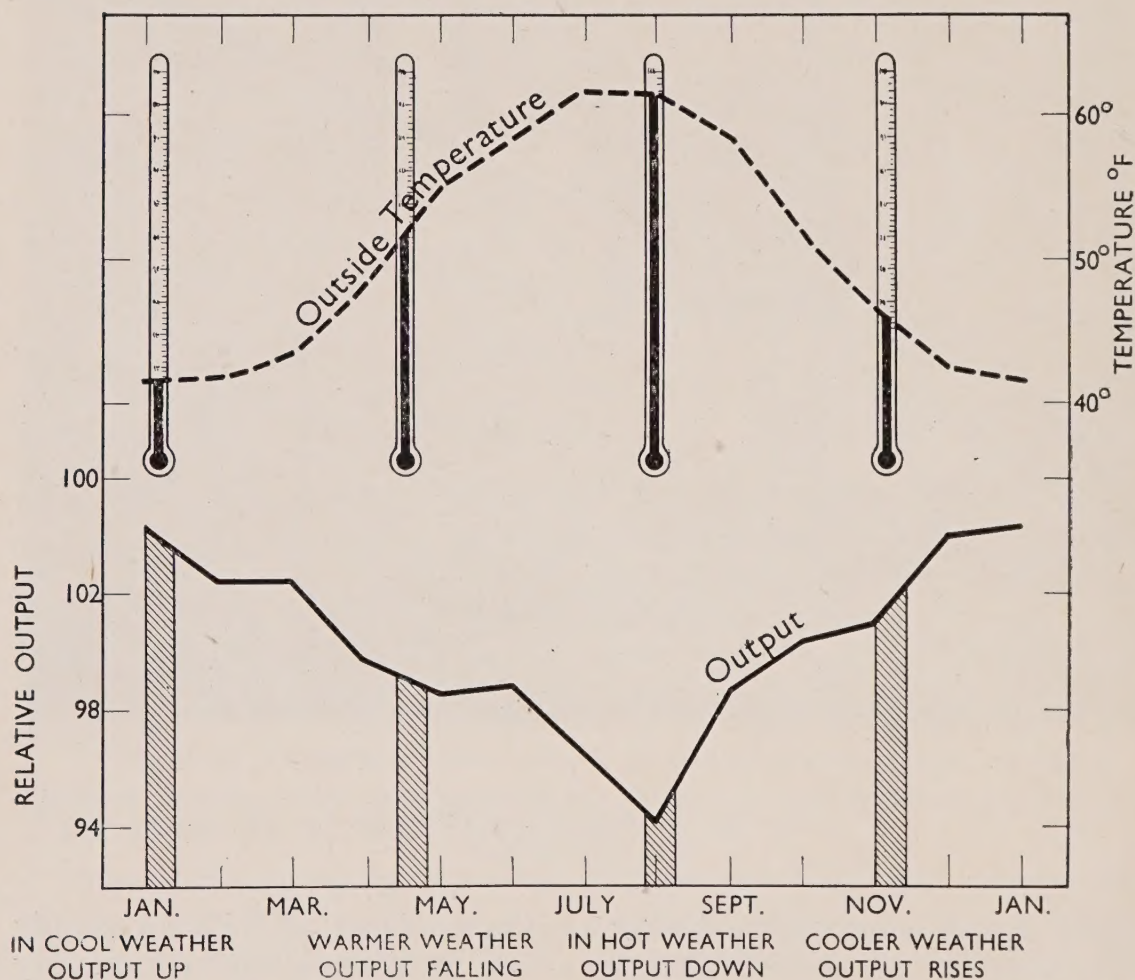


FIG. 3. SEASONAL VARIATIONS IN OUTPUT OF TINPLATE FACTORIES

to occur at really high temperatures, more moderate temperatures have their effect on the capacity for doing work. Much evidence showing the influence of excessive warmth on working efficiency has been accumulated. As an example, Fig. 3 shows the substantial diminution in the output of tinplate workers observed in hot weather. The upper curve shows the average monthly outside temperatures and the lower one shows the fluctuations in the average monthly output for five tinplate factories. There is a close connection between temperature and output. In the hottest month the output was about 10 per cent.

* It is recommended that in hot industries the drinking water should contain 10 grams of salt to the gallon of water. Common salt (sodium chloride) may be used, but it is preferable to use 6 grams of sodium chloride and 4 grams of potassium chloride to the gallon. Saline drinks can be made palatable by the addition of flavouring agents such as saccharin and oil of lemon.

below that for the coolest one. It is estimated that in the worst-ventilated of these factories the output on the hottest days was probably 30 per cent. less than in the coldest weather.

When tasks require considerable nimbleness of movement, uncomfortably low temperatures also tend to reduce efficiency, for the hands become chilled and their dexterity diminishes.

In various industries adverse temperature conditions have been shown to increase the risk of accidents. Thus, in munition factories during the war of 1914-18 it was found that accidents were at a minimum when the shop temperature was between 65° and 70° F. Fig. 4

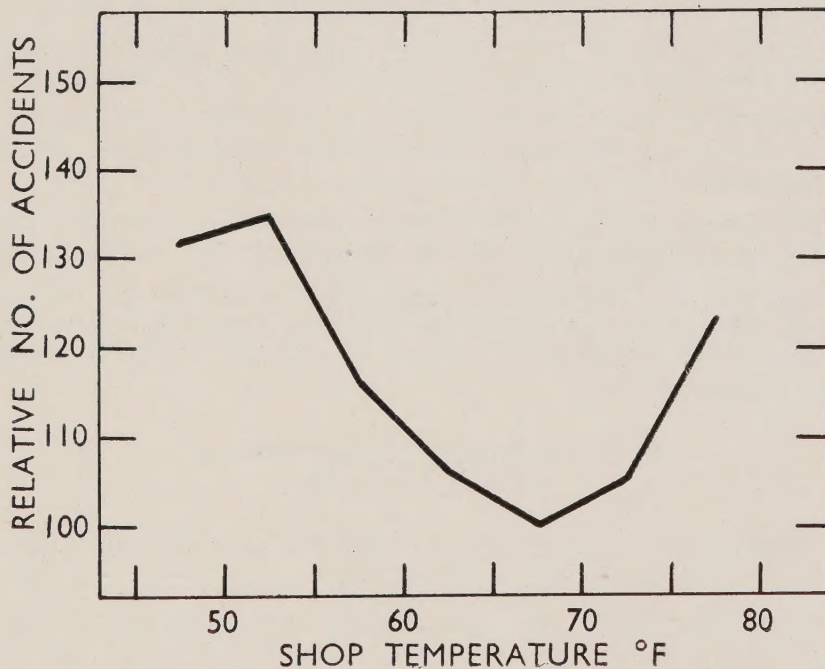


FIG. 4. ACCIDENT FREQUENCY IN RELATION TO TEMPERATURE

shows that when the temperature was much above or below that range the number of accidents increased substantially.

Conclusion

A very brief outline of the known requirements of good ventilation and heating has been given here, and readers wishing for more detailed information may consult the reports listed overleaf. In many factories the main cause of unsatisfactory ventilation and heating is that the existing arrangements are not properly used and looked after. Supervision of ventilation and heating should be the definite responsibility of one person or group of persons. Although specially trained engineers are needed to take exact measurements of air supply and air movement, in most cases it is common sense and interest that are chiefly necessary. Certainly, no Medical or Welfare Department, no Joint Production Committee, and indeed no man or woman worker, can afford to neglect the significance of proper ventilation and heating.

REFERENCES

(Items Nos. 2, 5 and 6 below are at present out of print, but copies are available for consultation in many libraries.)

(1) *Industrial Health in War*. Industrial Health Research Board Emergency Report No. 1 (1940). H.M. Stationery Office. Price 6d. (8d.).

(2) *The Warmth Factor in Comfort at Work*. Industrial Health Research Board Report No. 76 (1936). H.M. Stationery Office.

(3) *Ventilation of Factories*. Ministry of Labour and National Service Welfare Pamphlet No. 5 (4th edn., 1940). H.M. Stationery Office. Price 1s. 6d. (1s. 8d.).

(4) *Factory Ventilation in the Black-out*. Factory Department, Ministry of Labour and National Service Form 301 (Feb. 1942). H.M. Stationery Office.

(5) *The Influence of Hours of Work and of Ventilation on Output in Tinsplate Manufacture*. Industrial Fatigue Research Board Report No. 1 (1919). H.M. Stationery Office.

(6) *A Physiological Study of Ventilation and Heating in Certain Factories*. Industrial Fatigue Research Board Report No. 35 (1926). H.M. Stationery Office.

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(Prices in brackets include postage.)

Lighting and Seeing

A Reminder

For most people sight is the most important of the senses. Through our eyes we gain most of our knowledge of the world we live in, and through them we experience many of our pleasures. But, just because we use our eyes so constantly and automatically, we often forget how much they mean to us, and take too little care to make sure that we see as well as possible. Without always being very conscious of it, we are constantly influenced by what we see, and by whether we see easily or with some difficulty. It often takes a sudden improvement of illumination to make us realise how little we had before, and that we were straining our eyes in order to see properly. Clear vision has much to do with our feelings of cheerfulness, fitness, and energy. It also directly assists our efficiency at work and play, as well as our safety. But to see we need light as well as eyes. And even with the best of eyes, it all depends on lighting whether we see at all, and how well we see.

LIGHTING

During daytime there is usually an abundance of natural light out-of-doors. If we let a sufficient proportion of it into the buildings where we spend so many working hours, we shall have no reason for complaint. In many factories this is not done—and sometimes, perhaps, it cannot be done in war-time. But it is always possible to replace or supplement daylight with the necessary artificial light. Modern artificial lighting can be excellent, both in quantity and quality, and there is no good reason to-day for failure to light factories well—except in a few rare and special cases as, for instance, where light-sensitive photographic materials are made or, temporarily, owing to war-time shortage of materials. Ignorance of what is bad lighting cannot be pleaded; everyone has the experience of working in cheerful and comfortable natural daylight, and we can use this as a general standard by which to judge whether lighting is good or bad. In bad lighting, we feel a sense of strain in seeing. When this is only vague we often ignore it, especially if we are absorbed in some interesting occupation, and sometimes for this reason, and sometimes because we are unable to do anything about it, many of us live and work for long periods in badly lighted buildings. We thus abuse our eyes, lower our efficiency, and often spoil our “tempers”. While we are not indifferent to our surroundings, many of us too readily accept them as unalterable. We complain of bad lighting, but often make little effort to get it improved. The cost of lighting—small as it is—leads some people who have to provide it to persuade themselves that poor lighting is better

than it really is. This is being “penny wise and pound foolish”, for, in the long run, bad factory lighting never pays. Many investigations have shown that it lowers output, and its less easily measured ill-effects are certainly far-reaching and wholly uneconomic.

Principles of Good Factory Lighting

(a) *The Need for General Brightness.* Light in the factory is required not only for the purpose of seeing the work easily. One of its most important functions is to brighten the whole surroundings in which work is done. Good lighting makes us feel cheerful, alert, and willing to work. Brightness and colour influence our feelings, and these feelings have much to do with whether we are energetic and efficient or apathetic and inefficient. A dim factory is usually dismal and depressing, a bright one “as good as a tonic”.

It is not easy to over-rate the effects of brightness in the factory on the general outlook of the workers. Good general lighting is therefore important for this reason alone. And the general appearance of brightness will be much increased if walls and ceilings, plant and machinery are painted in pale colours, such as cream, instead of in dingy greys and browns. Light colours also help to prevent glare, which is frequently due to the extreme contrast of a bright light seen against a dark background.

Good general illumination in all parts of the factory also has other obvious advantages. It permits safe and rapid movement of persons and materials about the factory; it makes supervision and cleaning easier, and it is sufficient for the satisfactory performance of much of the work.

(b) *Lighting the Job.* There are many jobs, however, for which the lighting needs special consideration. In order to avoid eyestrain, and also to get maximum efficiency, it may be necessary to provide additional local lighting, or perhaps to arrange for light to fall from a particular direction.

As everyone knows by experience, the finer the details to be seen, the better the light required. But it is not generally known that the amount of light needed increases much more rapidly than the “finess” of the work. For example, if one job is twice as “fine” as another, much more than twice the illumination is needed to see it without undue difficulty. This is one of the “laws” of seeing disclosed by scientific investigation. Hence it may be necessary to have considerable differences in lighting for different jobs, in order to make it possible for each of them to be done, as far as possible, with equal efficiency and comfort. More than a hundred times as much light is needed for the “finest” as for the “roughest” work in factories.

Measuring Light

Light can easily be measured with a light meter. This instrument can be obtained in a very small and convenient size for factory use, and it measures light in units known as foot-candles. The light meter

is as easy to read as a thermometer, and should be widely known and used, in order to keep a check on the illumination available and to encourage proper maintenance of lighting installations.

What must and what should be done

Regulations* now in force, specifying minimum standards of lighting in factories, require the illumination at bench level, or on a horizontal plane 3 feet above floor level, to be not less than 6 foot-candles (with certain exceptions). This Order has a double purpose. Firstly, an illumination of 6 foot-candles enables ordinary work to be done with reasonable comfort and efficiency, though the Order does not affect the duty of employers to provide higher illumination for fine work. Secondly, the Order should usually ensure that the general appearance of the factory is sufficiently bright and cheerful. This second aim will not be achieved if the letter rather than the spirit of the law is observed—that is, if light is distributed only in a downward direction, and no direct light reaches the upper parts of walls and ceilings. Although this type of lighting may fulfil the requirements of the regulations, it is nevertheless *bad* lighting. The first of the accompanying photographs (Fig. 5) shows how depressing it can be. The second photograph (Fig. 6) shows some improvement, the third (Fig. 7) illustrates many lighting faults, while Figs. 8, 9 and 10 illustrate the much more satisfactory effect of different systems of artificial lighting, including some which closely resemble natural daylight.

A more detailed consideration of the features of good factory lighting is impossible in a short space. For the best results, the advice and planning of the lighting specialist is necessary.† The aim here is to indicate broadly the effects to be aimed at, and to point out that good lighting is important, not only because it enables us to see our work well, but also because it makes us feel happier and more energetic. In many factories the existing systems of lighting are good, and attention to cleaning and maintenance is the chief need. In one factory it was recently found that lighting was improved by 50 per cent., after the fittings had been cleaned and dusted. The moral of this, especially in these days of fuel economy, needs no stressing.

* S.R. and O., 1941, No. 94, Factories (Standards of Lighting) Regulations.

† Employers who are not in touch with a competent lighting engineer can obtain advice gratis from the National Industrial Electric Lighting Service, 2 Savoy Hill, London, W.C.2, or, in the case of gas lighting, from the Joint Lighting Committee of the Gas Industry, Gas Industry House, Grosvenor Place, London, S.W.1.

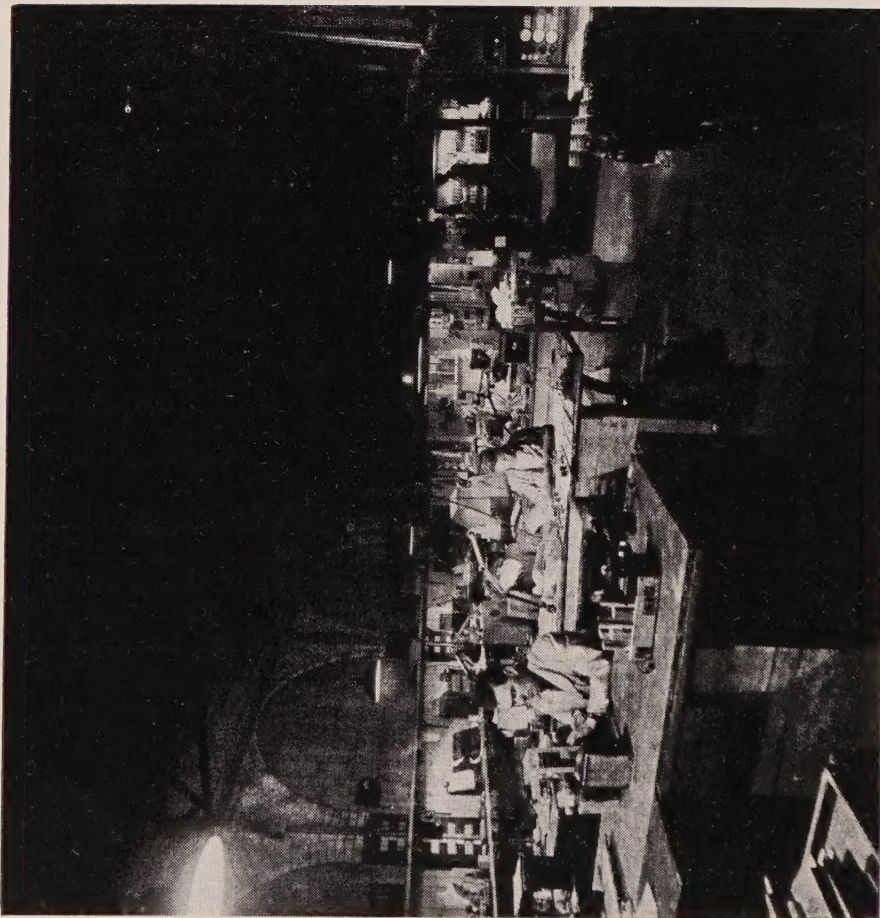


FIG. 5. AN EXAMPLE OF BAD LIGHTING

In this factory there is sufficient lighting of the actual work, but the general appearance is dismal and depressing. The workers dubbed it "the dump". Note the gloom of the upper part, and the heavy shadows on bench and floor.

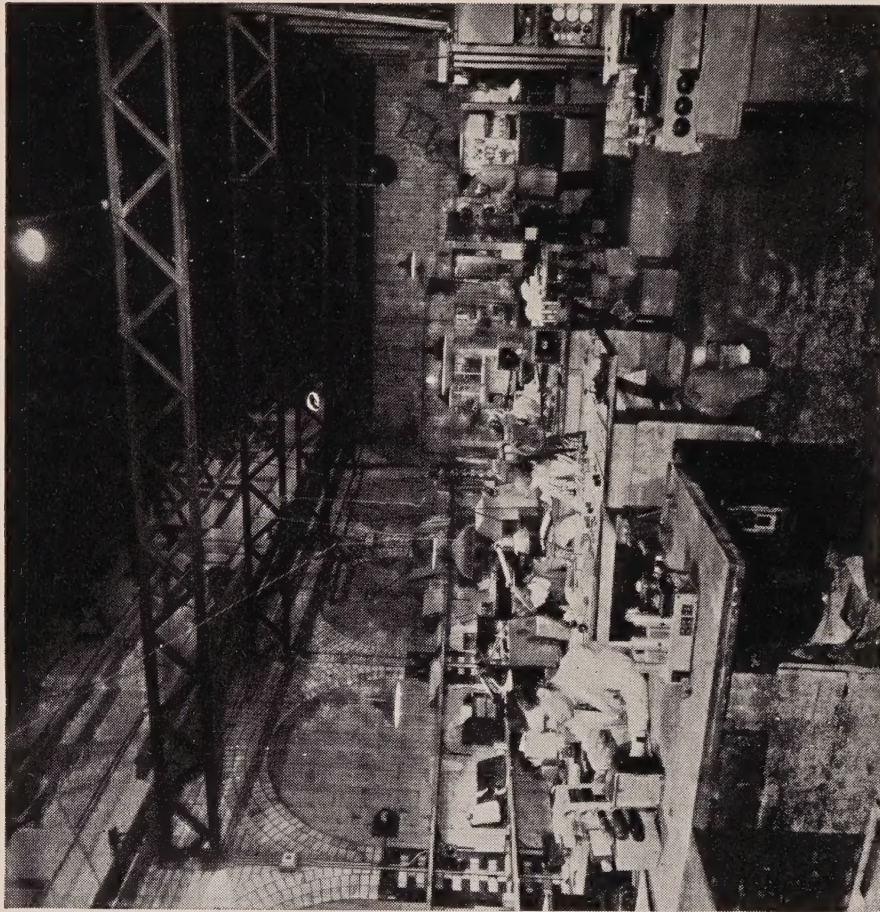


FIG. 6. SOME LIGHTING DEFECTS REMOVED

The whole aspect of the place is changed by a little high level lighting. Something of the normal daylight appearance is restored, and the harsh shadows have gone. Improvisation has partly removed the defects of the previous lighting, but much better results could be obtained with a well-planned installation.

[Photographs by courtesy of General Electric Co., Ltd.]



FIG. 7. GLARE AND GLOOM

Here is an example of thoroughly bad artificial lighting. The light is very unevenly distributed; there are heavy shadows and extreme brightness contrasts. Glare and gloom are outstanding features, and are as unnecessary as they are undesirable.



FIG. 8. MODERN LIGHTING IN A SEWING-ROOM

This is a modern installation for artificial lighting, giving good general illumination over the whole working area. Glare is not pronounced, but there is a "forest" of relatively bright patches in the field of view. This would be less apparent if the fittings were mounted higher, and the roof background made brighter by some direct lighting.

[Photographs by courtesy of Electric Lamp Manufacturers Association]

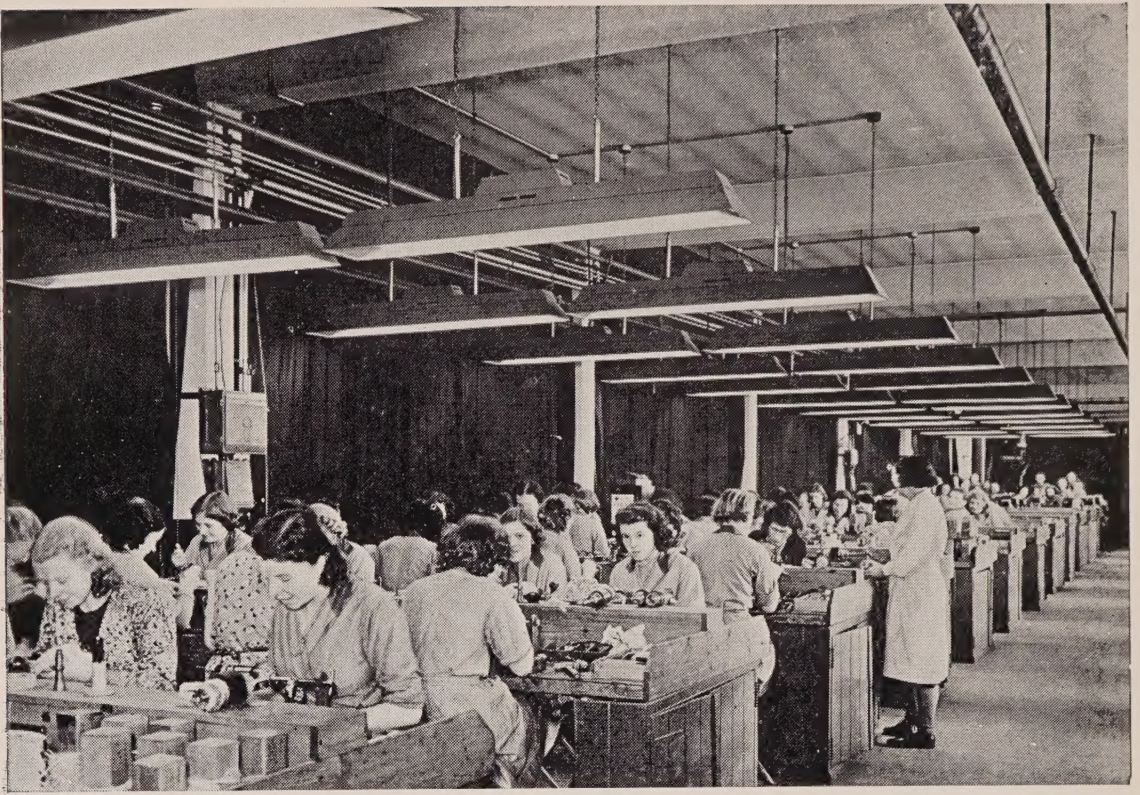


FIG. 9. LIGHTING BY TUBULAR FLUORESCENT LAMPS

Artificial lighting by tubular fluorescent lamps, giving good illumination resembling daylight in colour. There is no glare, and the large area and low brightness of the light sources almost "naturalise" this form of lighting. The black curtains should be lined with pale-coloured material to give greater brightness and reflect more light on to the work.

[Photograph by courtesy of General Electric Co., Ltd.]



FIG. 10. ARTIFICIAL WINDOWS IN A FOUNDRY

In this foundry, artificial windows are used to "beat the black-out" and provide apparently natural lighting. Fluorescent tubular lamps are used. The effects are most satisfactory, and this method of artificial lighting could be widely adopted in factories.

[Photograph by courtesy of British Thomson Houston Co., Ltd.]

SEEING

How the Eyes Work

The provision of good lighting cannot entirely prevent eyestrain with every kind of work. It may be impossible to see fine detail, even with excellent illumination, unless the eyes are brought very close to the object. To understand why this causes eyestrain, it is necessary to have some idea of the mechanism of the eye.

To see clearly, the eye has to adjust its focus according to the distance of the object to be seen. If the object is focussed correctly it is sharp and clear, and objects nearer or further away appear misty and blurred. Many people have done enough photography to understand the importance of correct focussing. In the eye, it is by altering the curvature of the lens that focussing is achieved, instead of by altering the distance between the lens and sensitive film, as in the camera. This alteration of lens curvature is brought about by small muscles, and is normally done quite unconsciously and without effort. It is called "accommodation".

In addition to focussing, or accommodating for distance of view, the eyes make another adjustment—called "convergence"—by which both eyes are directed simultaneously on the same object. When the eyes change their focus, the muscles which cause convergence also come into play, and in this way we get single vision of the object looked at. But, if the strength of these muscles is not properly balanced, some of them will be strained in the effort to maintain proper convergence.

To examine very small objects, we have to look closely at them. In this process the muscles responsible for accommodation and convergence are called upon to work to full capacity. They cannot do so for long without getting tired. In some people, certain eye muscles are relatively weak, and are thus more easily fatigued if much "close work" has to be done.

Spectacles for "Close Work"

Relief of the strain to which "close" workers are subjected—even when their vision and their eye muscles are normal—can be secured without difficulty by the use of special spectacles.

If no such aid is used, and the task calls for very near vision, the worker will find it necessary to rest his eyes frequently by looking into the distance, thus relaxing the eye muscles. Without spectacles, the frequency and length of the necessary rests will obviously take up time which might otherwise have been spent in production. By using some artificial aid, and so limiting the effort required of the eyes themselves, workers will not only suffer less fatigue but will also get more work done. A similar principle is involved when, by using a jack to lift a motor-car, or block and tackle to raise a heavy casting, the muscular effort required is reduced to a reasonable amount which is not rapidly fatiguing.

Of course, rests are taken by everyone, and they vary in length and frequency according to the nature of the work. Complaints of severe eyestrain are less common than they would be if no such defensive measure were adopted. But the absence of complaints does not necessarily mean that a particular type of work is not trying to the eyes. When the need for good output is urgent—as at the present time—the risk of overstrain is greatest, even though its consequences can least be afforded.

Maximum output can be achieved only if the number and duration of the eye rests necessary to avoid undue fatigue are reduced to a minimum. These rest-pauses reduce the time available for effective work in two ways. The first way is obvious—the time occupied by the rest-pause is lost to production. The second way is not so obvious, but it is important—time is also lost *after* the rest-pause, since the eyes require an appreciable period in which to become refocussed for near

vision. This time—although influenced by the age and other characteristics of the eyes—is longer than is generally realised. Thus it is clear that if frequent rests for the eyes are necessary, much time will be lost for production. We certainly cannot afford to lose time unnecessarily, and, in any case, it is foolish to suffer needless strain by failure to provide or use scientifically designed aids to sight for difficult work.

Even persons of normal sight need spectacles when doing work that has very fine detail. Several types of suitable glasses are available, and an example is illustrated in Fig. 11. As a general rule, the use of glasses should be considered whenever the details of well lighted work* cannot be seen clearly unless the eyes are brought within 10 inches



FIG. 11. AVOIDING EYESTRAIN

An example of magnifying spectacles for very fine work. Other types are available, and for many processes "weaker" lenses, combined with prisms, are suitable and the spectacles are not unusual in appearance.

[Photo by courtesy of W. Watson & Sons, Ltd.]

of it. The use of such glasses does not make the worker dependent on them when not at work. They are intended only for use in the factory. Magnifiers which can be mounted on the bench are an alternative to spectacles, and these may sometimes prove more convenient.

Spectacles for Defective Sight

Many people experience eyestrain in doing ordinary work because they have defects of vision. In some factories, the Factory Medical

* The lighting code issued by the Illuminating Engineering Society is quoted by the Departmental Committee on Factory Lighting as a guide to the values of illumination suitable for tasks requiring more than 6 foot-candles.

Officer tests the eyes of all new workers and advises those with defective vision to obtain glasses, prescribed by an expert, before starting work.

This practice prevents much eyestrain and spoilt work, and is strongly to be recommended. Many people are unaware that they have slight defects of vision, and are pleasantly surprised at the improvement resulting from glasses. However, it cannot be too emphatically stated that the prescription of suitable glasses, like the prescription of suitable factory lighting, is a matter for the appropriate qualified expert, who must take into account the nature of the work as well as the vision of the worker. Unsuitable glasses may do much more harm than good.

How Improved Vision affects Work

The use of suitable glasses will often provide immediate relief from eyestrain, but in some cases the effect on output may become apparent only after a certain time has elapsed.

With experienced workers, the rate of work is the result of well-established habits, and habits are not quickly changed. Also, workers on delicate jobs may not be able to increase the rate of working, even with improved lighting and vision, until they have developed greater skill. The new worker has to become skilled both with his hands and with his eyes. This skill of the eyes is very important in relation to production, and is acquired only by experience. For example, the trained eye of a weaver sees a broken thread in his warp much more rapidly than the untrained eye of a casual observer, even though the observer may have better vision than the weaver. However, the period of training and experience needed for acquiring visual skill may be considerably shortened by the use of glasses which make seeing easier and more comfortable.

Conclusion

Scientific research has taught us much about both lighting and seeing. This knowledge should be put to practical use in our daily life in the factory. Good lighting, by promoting good seeing, makes work more pleasant and workers more efficient.

Individuals can and should take care of their own eyes, on which they depend for their livelihood as well as for much of their enjoyment of life. For instance, any worker who has an eye accident, or who gets a foreign body in the eye, should at once seek first-aid treatment. Similarly, competent advice should be sought if symptoms of eyestrain are experienced, such as aching and burning of the eyes, redness of the lids and headache.

Finally, the maintenance of good lighting depends upon the regular cleaning, at suitable intervals, of windows, lamps and lighting fittings, and effective arrangements for such maintenance should be made in every factory.

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